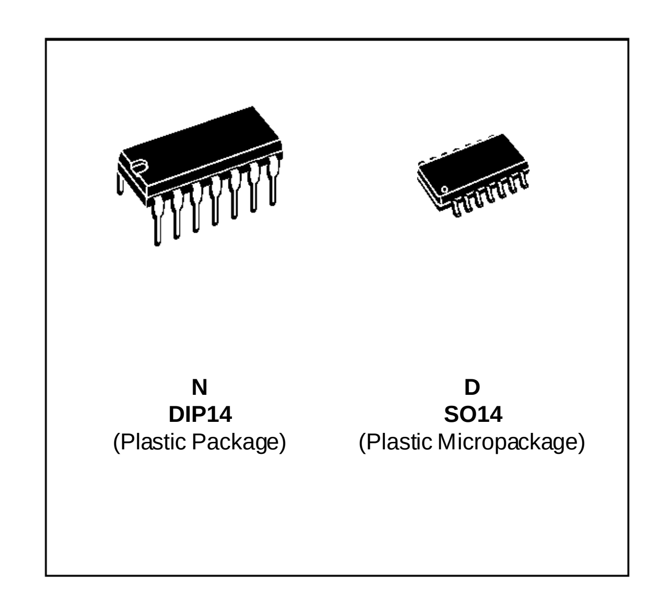


LM124,A - LM224,A LM324,A

LOW POWER QUAD OPERATIONAL AMPLIFIERS

- LARGE VOLTAGE GAIN : 100dB
- VERY LOW SUPPLY CURRENT/AMPLI : 375µA
- LOW INPUT BIAS CURRENT : 20nA
- LOW INPUT OFFSET VOLTAGE : 2mV
- LOW INPUT OFFSET CURRENT : 2nA
- WIDE POWER SUPPLY RANGE :
  SINGLE SUPPLY : +3V TO +30V
  DUAL SUPPLIES : ±1.5V TO ±15V



DESCRIPTION

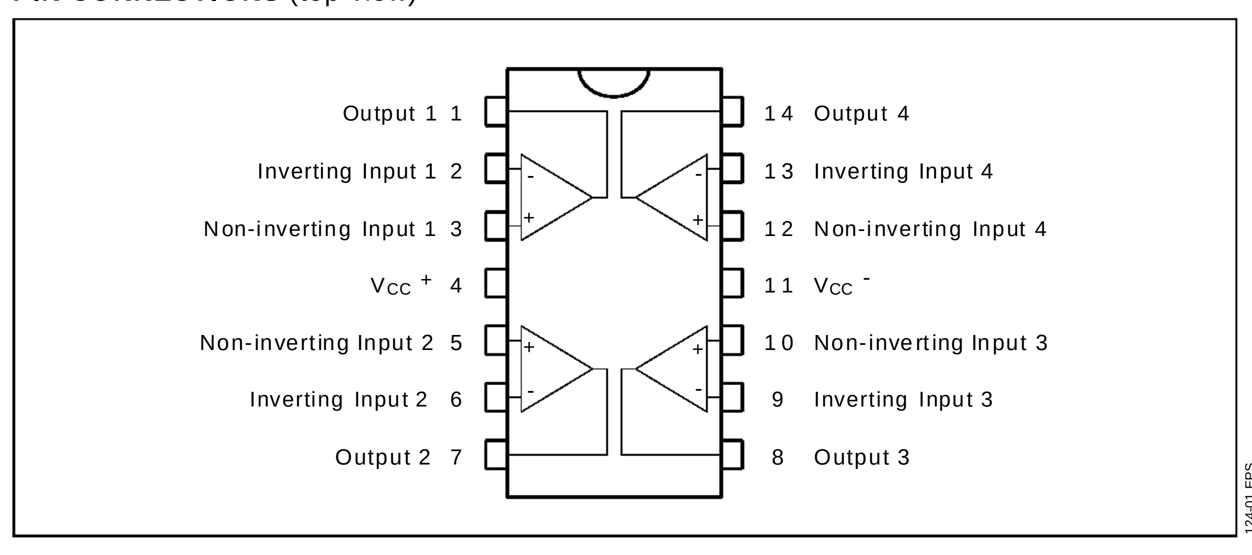
These circuits consist of four independent, high gain, internally frequency compensated operational amplifiers which were designed specifically for automotive and industrial control systems. They operate from a single power supply over a wide range of voltages. Operation from split power supplies is also possible and the low power supply current drain is independent of the magnitude of the power supply voltage.

ORDER CODES

Part Number	Temperature Range	Package	
		N	D
LM124,A	-55°C, +125°C	•	•
LM224,A	-40°C, +105°C	•	•
LM324,A	0°C, +70°C	•	•
Example : LM224N			

124-01.TBL

PIN CONNECTIONS (top view)



SCHEMATIC DIAGRAM (1/4 LM124)

124-02.EPS

ABSOLUTE MAXIMUM RATINGS

Symbol	Parameter	LM124,A	LM224,A	LM324,A	Unit
V_{cc}	Supply Voltage	±16 or 32			V
V_i	Input Voltage	-0.3 to +32			V
V_{id}	Differential Input Voltage - (*)	+32	+32	+32	V
P_{tot}	Power Dissipation N Suffix D Suffix	500 -	500 400	500 400	mW mW
-	Output Short-circuit Duration - (note 1)	Infinite			
I_{in}	Input Current – (note 6)	50	50	50	mA
T_{oper}	Operating Free Air Temperature Range	-55 to +125	-40 to +105	0 to +70	°C
T_{stg}	Storage Temperature Range	-65 to +150	-65 to +150	-65 to +150	°C

124-02.TBL

(*) - Either or both input voltages must not exceed the magnitude of V_{CC}^{+} or V_{CC}^{-}.



ELECTRICAL CHARACTERISTICS

V_{CC}^{+} = +5V, V_{CC}^{-} = Ground, V_O = 1.4V, T_{amb} = +25°C
(unless otherwise specified)

Symbol	Parameter	LM124A - LM224A LM324A			LM124 - LM224 LM324			Unit
		Min.	Typ.	Max.	Min.	Typ.	Max.	
V_{io}	Input Offset Voltage (note 3) T_{amb} = +25°C LM324 $T_{min.} \leq T_{amb} \leq T_{max.}$ LM324		 2	 3 5		 2	 5 7 7 9	mV
I_{io}	Input Offset Current T_{amb} = +25°C $T_{min.} \leq T_{amb} \leq T_{max.}$		 2	 10 30		 2	 30 100	nA
I_{ib}	Input Bias Current (note 2) T_{amb} = +25°C $T_{min.} \leq T_{amb} \leq T_{max.}$		 20	 50 100		 20	 150 300	nA
A_{vd}	Large Signal Voltage Gain (V_{CC}^{+} = +15V, R_L = 2kΩ, V_O = 1.4V to 11.4V) T_{amb} = +25°C $T_{min.} \leq T_{amb} \leq T_{max.}$	 50 25	 100		 50 25	 100		V/mV
SVR	Supply Voltage Rejection Ratio ($R_S \leq$ 10kΩ) (V_{CC}^{+} = 5V to 30V) T_{amb} = +25°C $T_{min.} \leq T_{amb} \leq T_{max.}$	 65 65	 110		 65 65	 110		dB
I_{CC}	Supply Current, all Amp, no load T_{amb} = +25°C V_{CC} = +5V V_{CC} = +30V $T_{min.} \leq T_{amb} \leq T_{max.}$ V_{CC} = +5V V_{CC} = +30V		 0.7 1.5 0.8 1.5	 1.2 3 1.2 3		 0.7 1.5 0.8 1.5	 1.2 3 1.2 3	mA
V_{icm}	Input Common Mode Voltage Range (V_{CC} = +30V) - (note 4) T_{amb} = +25°C $T_{min.} \leq T_{amb} \leq T_{max.}$	 0 0		 V_{CC} -1.5 V_{CC} -2	 0 0		 V_{CC} -1.5 V_{CC} -2	V
CMR	Common-mode Rejection Ratio ($R_S \leq$ 10kΩ) T_{amb} = +25°C $T_{min.} \leq T_{amb} \leq T_{max}$	 70 60	 80		 70 60	 80		dB
I_o	Output Short-circuit Current (V_{id} = +1V) V_{CC} = +15V, V_o = +2V	 20	 40	 60	 20	 40	 60	mA
I_{sink}	Output Sink Current (V_{id} = -1V) V_{CC} = +15V, V_o = +2V V_{CC} = +15V, V_o = +0.2V	 10 12	 20 50		 10 12	 20 50		 mA µA

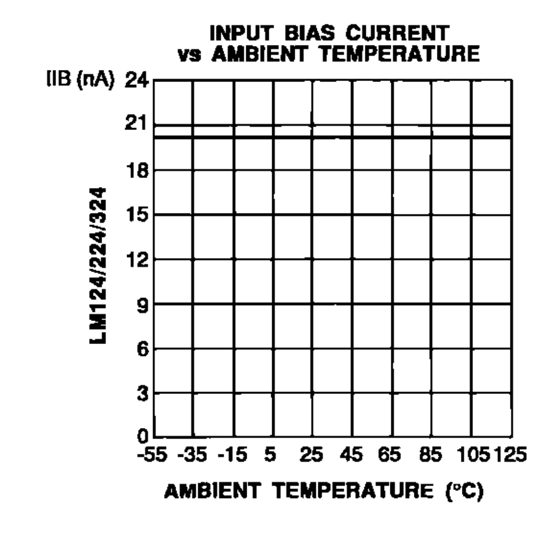
124-03.TBL

ELECTRICAL CHARACTERISTICS (continued)

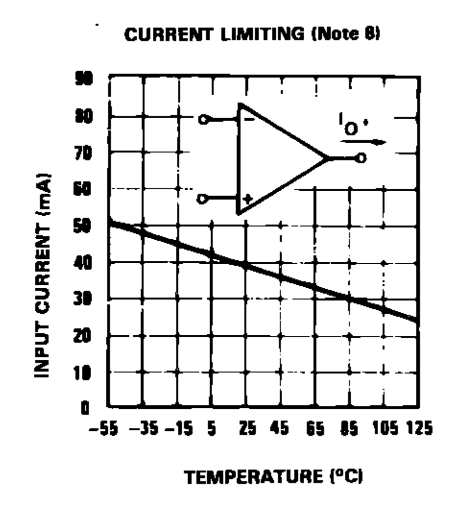
Symbol	Parameter	LM124A - LM224A LM324A			LM124 - LM224 LM324			Unit
		Min.	Typ.	Max.	Min.	Typ.	Max.	
V_{OH}	High Level Output Voltage (V_{CC} = +30V) T_{amb} = +25°C R_L = 2kΩ $T_{min.} \leq T_{amb} \leq T_{max.}$ T_{amb} = +25°C R_L = 10kΩ $T_{min.} \leq T_{amb} \leq T_{max.}$ (V_{CC} = +5V, R_L = 2kΩ) T_{amb} = +25°C $T_{min.} \leq T_{amb} \leq T_{max.}$	 26 26 27 27 3.5 3	 27 28		 26 26 27 27 3.5 3	 27 28		V
V_{OL}	Low Level Output Voltage (R_L = 10kΩ) T_{amb} = +25°C $T_{min.} \leq T_{amb} \leq T_{max.}$		 5	 20 20		 5	 20 20	mV
SR	Slew Rate (V_{CC} = 15V, V_I = 0.5 to 3V, R_L = 2kΩ, C_L = 100pF, T_{amb} = +25°C, unity gain)		0.4			0.4		V/µs
GBP	Gain Bandwidth Product (V_{CC} = 30V f = 100kHz, T_{amb} = +25°C, V_{in} = 10mV R_L = 2kΩ, C_L = 100pF)		1.3			1.3		MHz
THD	Total Harmonic Distortion (f = 1kHz, A_V = 20dB, R_L = 2kΩ, V_O = $2V_{pp}$ C_L = 100pF, T_{amb} = +25°C, V_{CC} = 30V)		0.015			0.015		%
e_n	Equivalent Input Noise Voltage (f = 1kHz, R_s = 100Ω, V_{CC} = 30V)		40			40		$\frac{nV}{\sqrt{Hz}}$
DV_{io}	Input Offset Voltage Drift		7	30		7	30	µV/°C
DI_{IO}	Input Offset Current Drift		10	200		10	200	pA/°C
V_O1/V_O2	Channel Separation (note 5) 1kHz ≤ f ≤ 20kHz		120			120		dB

124-04.TBL

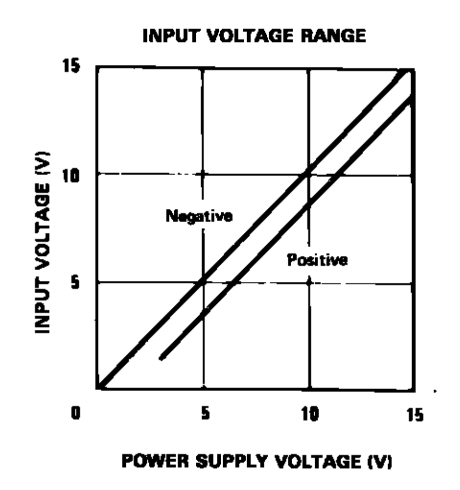
Notes :
1. Short-circuits from the output to V_{CC} can cause excessive heating if V_{CC} > 15V. The maximum output current is approximately 40mA independent of the magnitude of V_{CC}. Destructive dissipation can result from simultaneous short-circuit on all amplifiers.
2. The direction of the input current is out of the IC. This current is essentially constant, independent of the state of the output so no loading change exists on the input lines.
3. V_o = 1.4V, R_s = 0Ω, 5V < V_{CC}^+ < 30V, 0 < V_{ic} < V_{CC}^+ - 1.5V
4. The input common-mode voltage of either input signal voltage should not be allowed to go negative by more than 0.3V. The upper end of the common-mode voltage range is V_{CC}^+ - 1.5V, but either or both inputs can go to +32V without damage.
5. Due to the proximity of external components insure that coupling is not originating via stray capacitance between these external parts. This typically can be detected as this type of capacitance increases at higher frequences.
6. This input current only exists when the voltage at any of the input leads is driven negative. It is due to the collector-base junction of the input PNP transistor becoming forward biased and thereby acting as input diodes clamps. In addition to this diode action, there is also NPN parasitic action on the IC chip. this transistor action can cause the output voltages of the Op-amps to go to the V_{CC} voltage level (or to ground for a large overdrive) for the time duration than an input is driven negative.
   This is not destructive and normal output will set up again for input voltage higher than -0.3V.



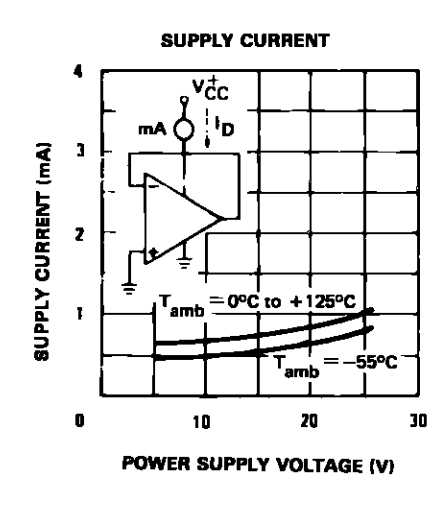
124-03.EPS



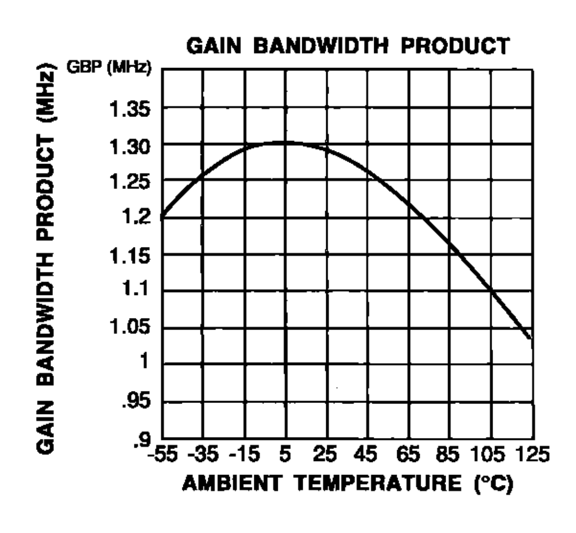
124-04.EPS



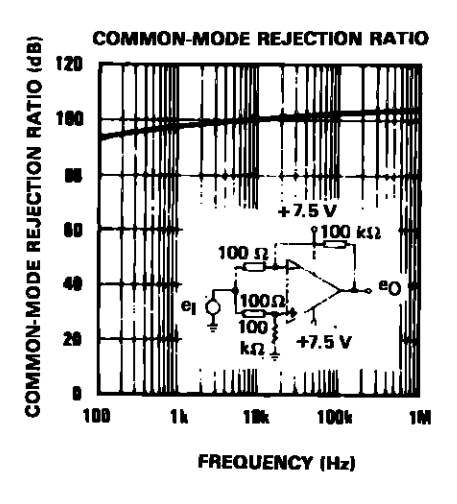
124-05.EPS



124-06.EPS

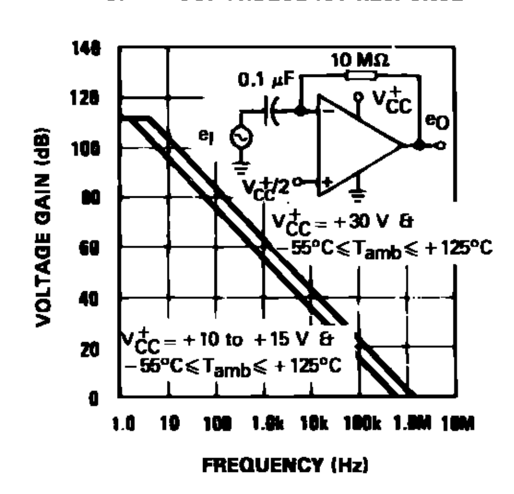


124-07.EPS

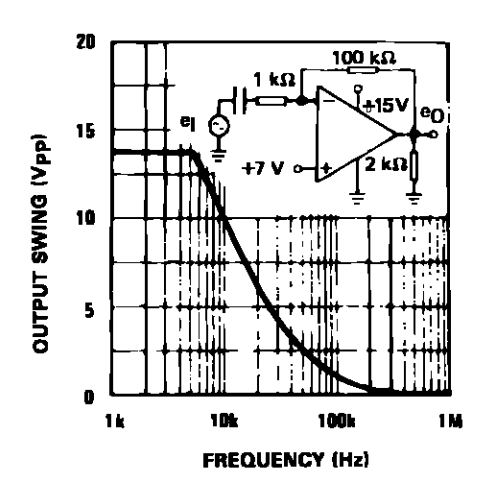


124-08.EPS

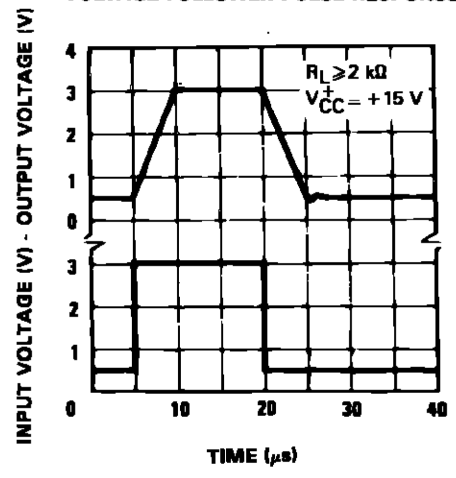
OPEN LOOP FREQUENCY RESPONSE



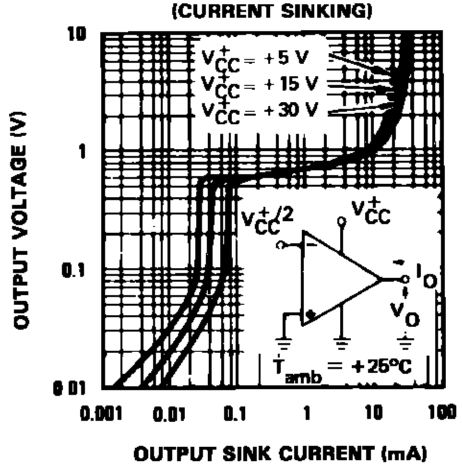
LARGE SIGNAL FREQUENCY RESPONSE



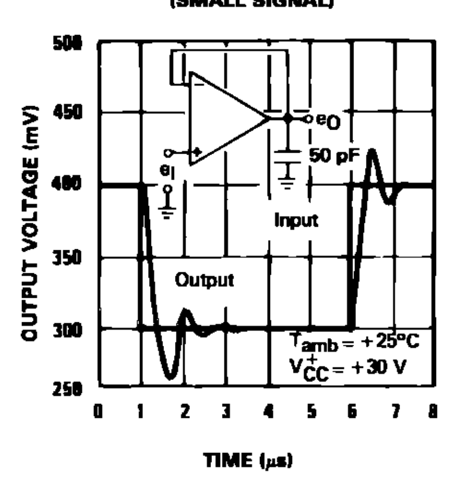
VOLTAGE FOLLOWER PULSE RESPONSE



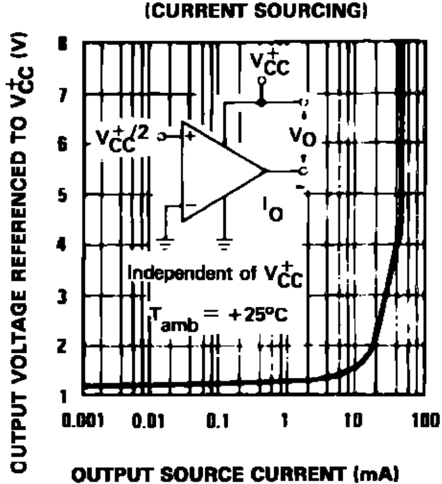
OUTPUT CHARACTERISTICS (CURRENT SINKING)



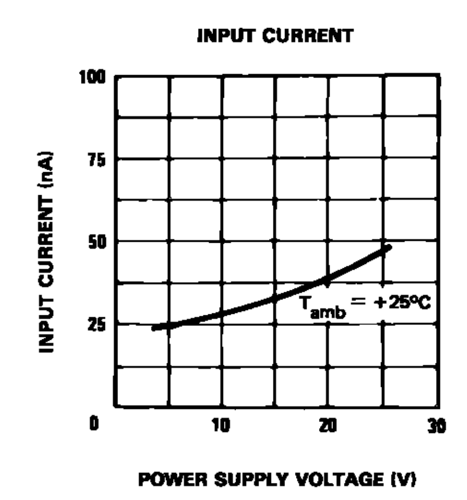
VOLTAGE FOLLOWER PULSE RESPONSE (SMALL SIGNAL)

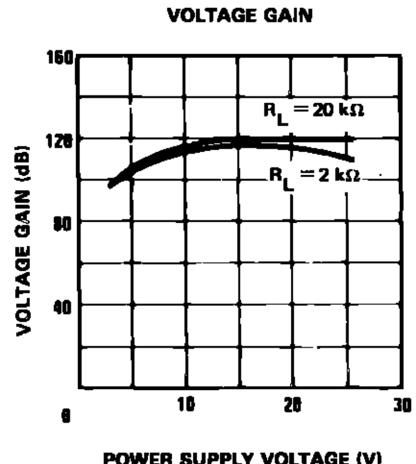


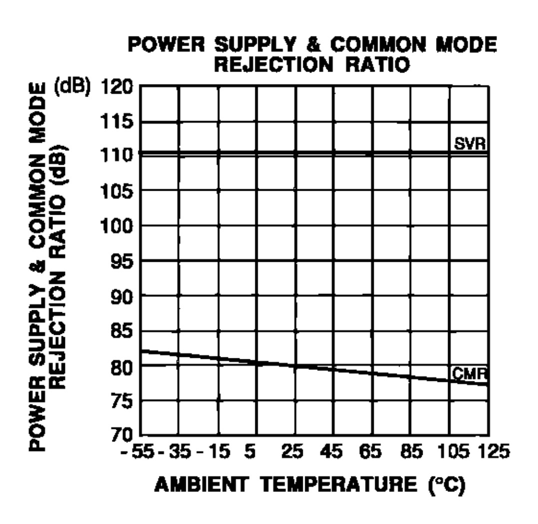
OUTPUT CHARACTERISTICS (CURRENT SOURCING)

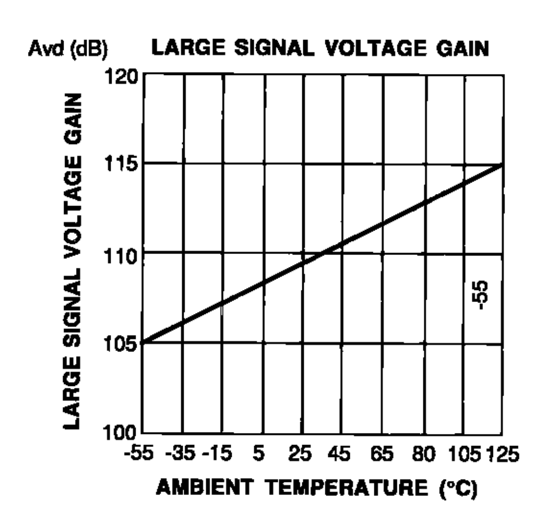


124-09.EPS



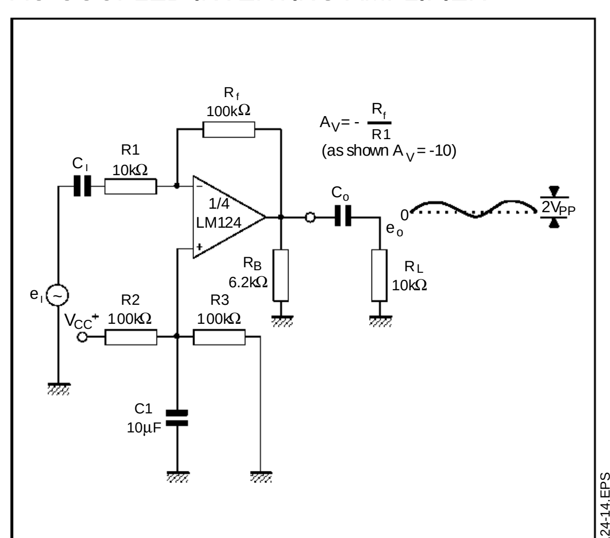




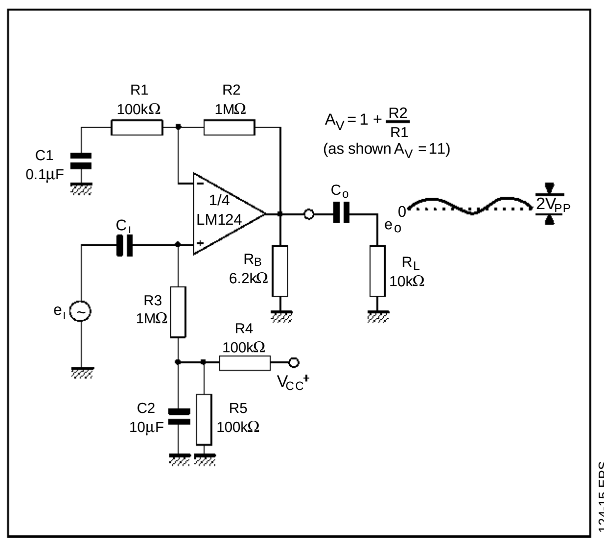


TYPICAL SINGLE - SUPPLY APPLICATIONS

AC COUPLED INVERTING AMPLIFIER

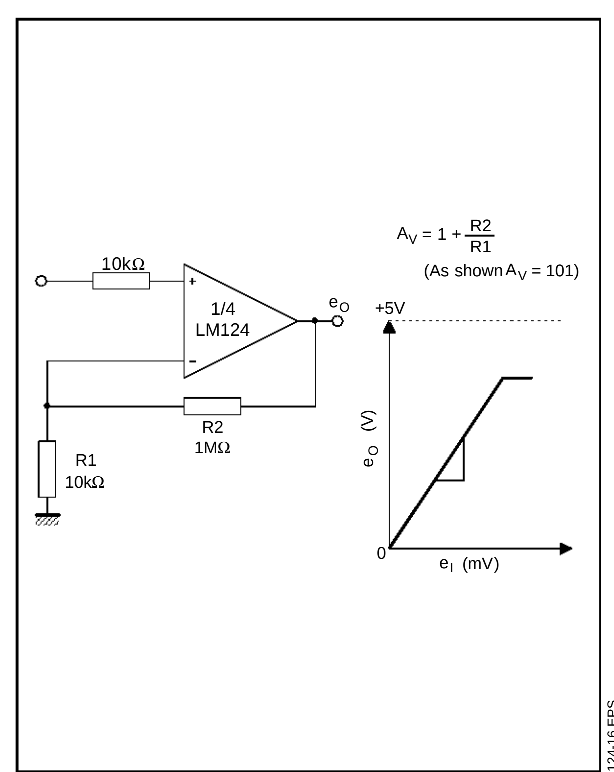


AC COUPLED NON-INVERTING AMPLIFIER

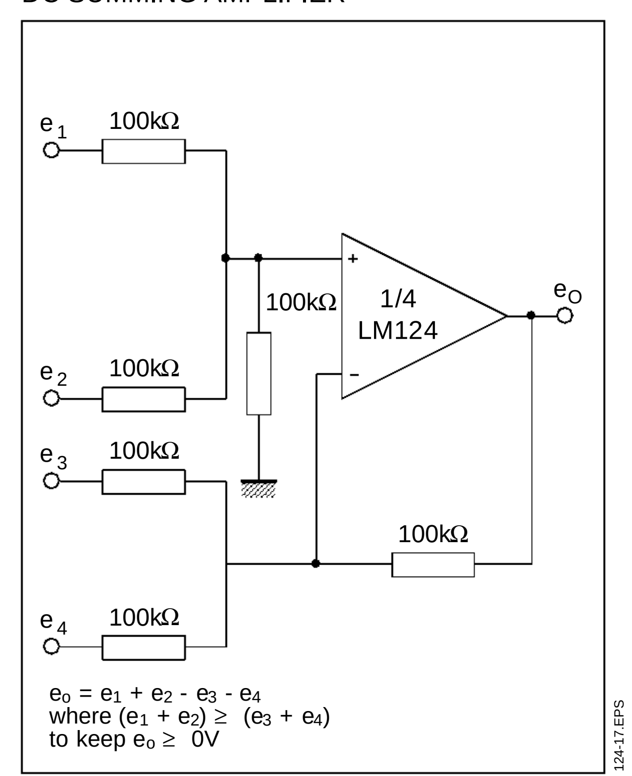


TYPICAL SINGLE - SUPPLY APPLICATIONS

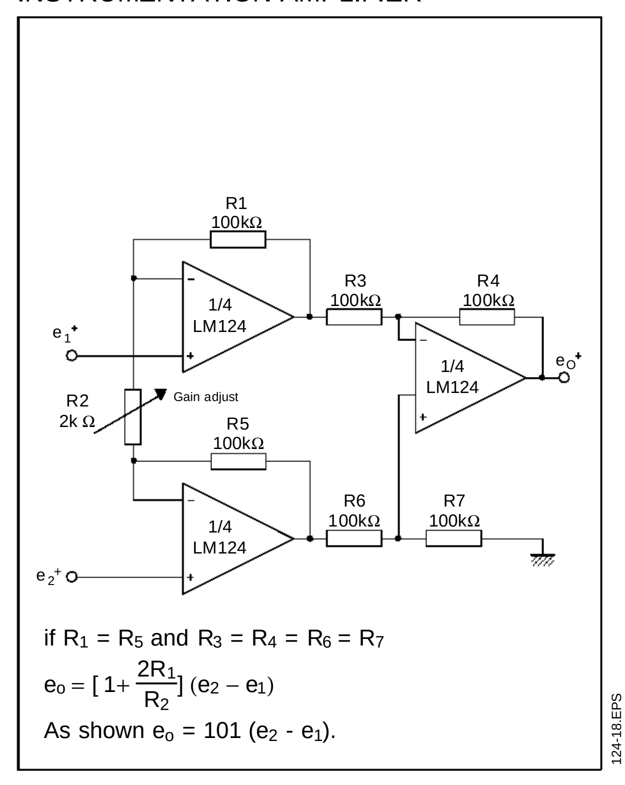
NON-INVERTING DC GAIN



DC SUMMING AMPLIFIER



HIGH INPUT Z ADJUSTABLE GAIN DC INSTRUMENTATION AMPLIFIER

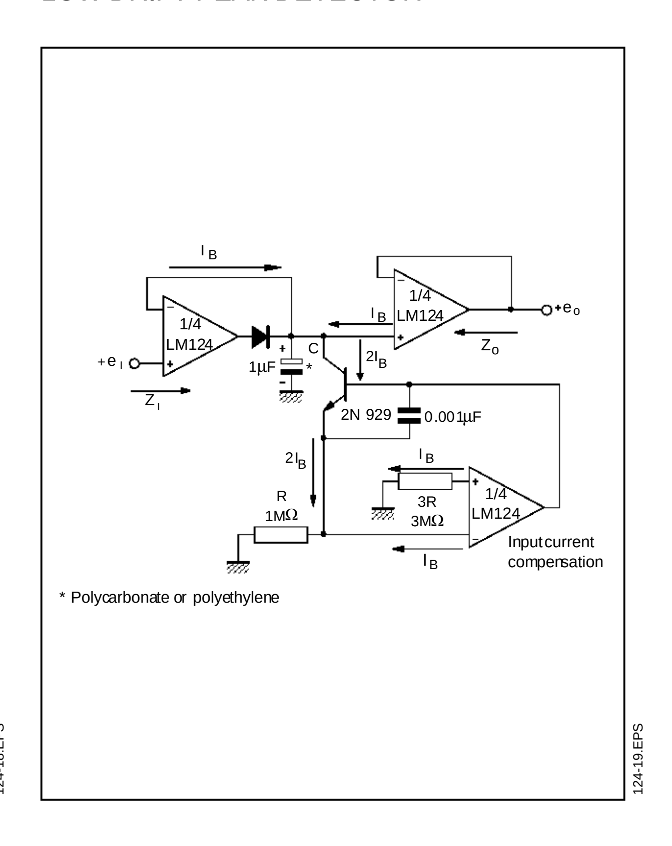


if $R_1 = R_5$ and $R_3 = R_4 = R_6 = R_7$

$$e_o = \left[1 + \frac{2R_1}{R_2}\right](e_2 - e_1)$$

As shown $e_o = 101\,(e_2 - e_1)$.

LOW DRIFT PEAK DETECTOR



TYPICAL SINGLE - SUPPLY APPLICATIONS

ACTIVER BANDPASS FILTER

R1 100kΩ
C1 330pF
R5 470kΩ
1/4 LM124
e_1
R4 10MΩ
C2 330pF
R3 10kΩ
R6 470kΩ
e_O
R7 100kΩ
V_{CC}^+
R8 100kΩ
C3 10µF

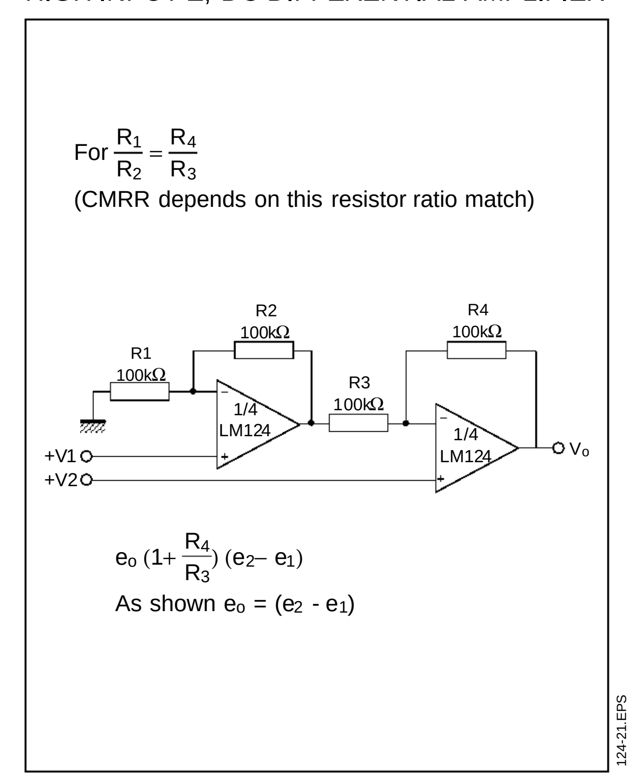
F_O = 1kHz

Q = 50

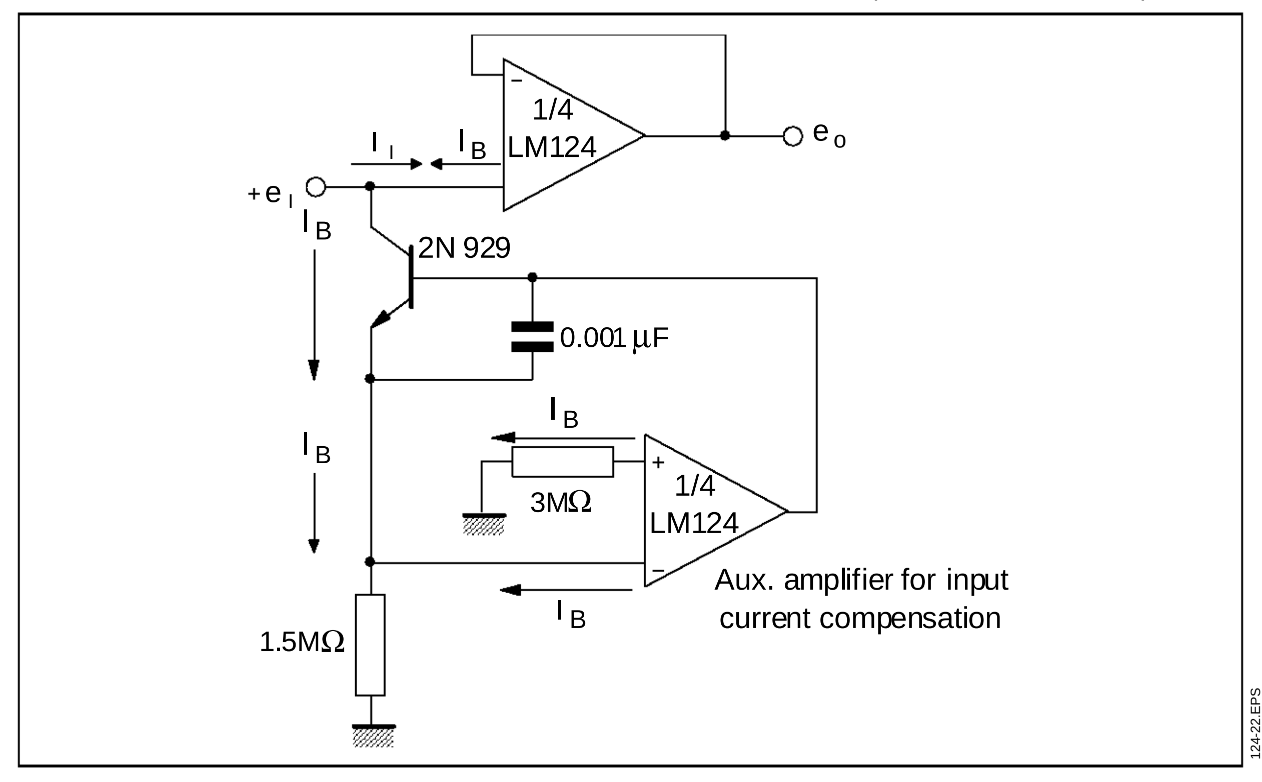
A_V = 100 (40dB)

124-20.EPS

HIGH INPUT Z, DC DIFFERENTIAL AMPLIFIER

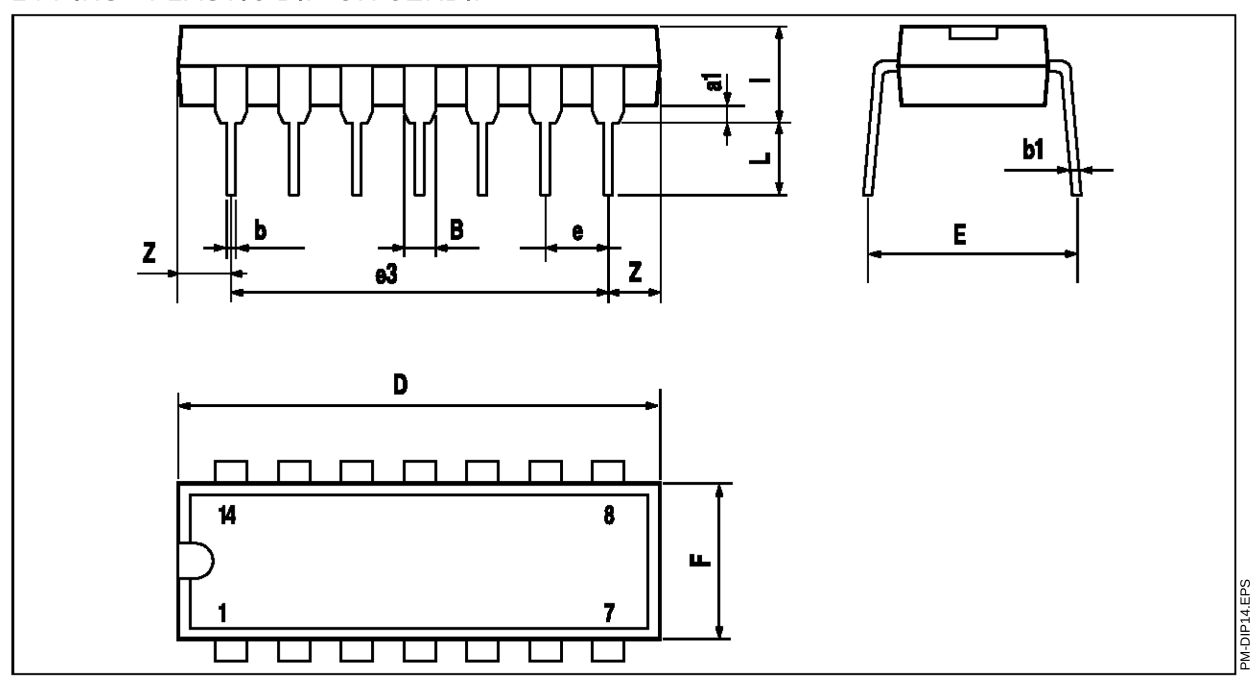


USING SYMMETRICAL AMPLIFIERS TO REDUCE INPUT CURRENT (GENERAL CONCEPT)



PACKAGE MECHANICAL DATA

14 PINS - PLASTIC DIP OR CERDIP

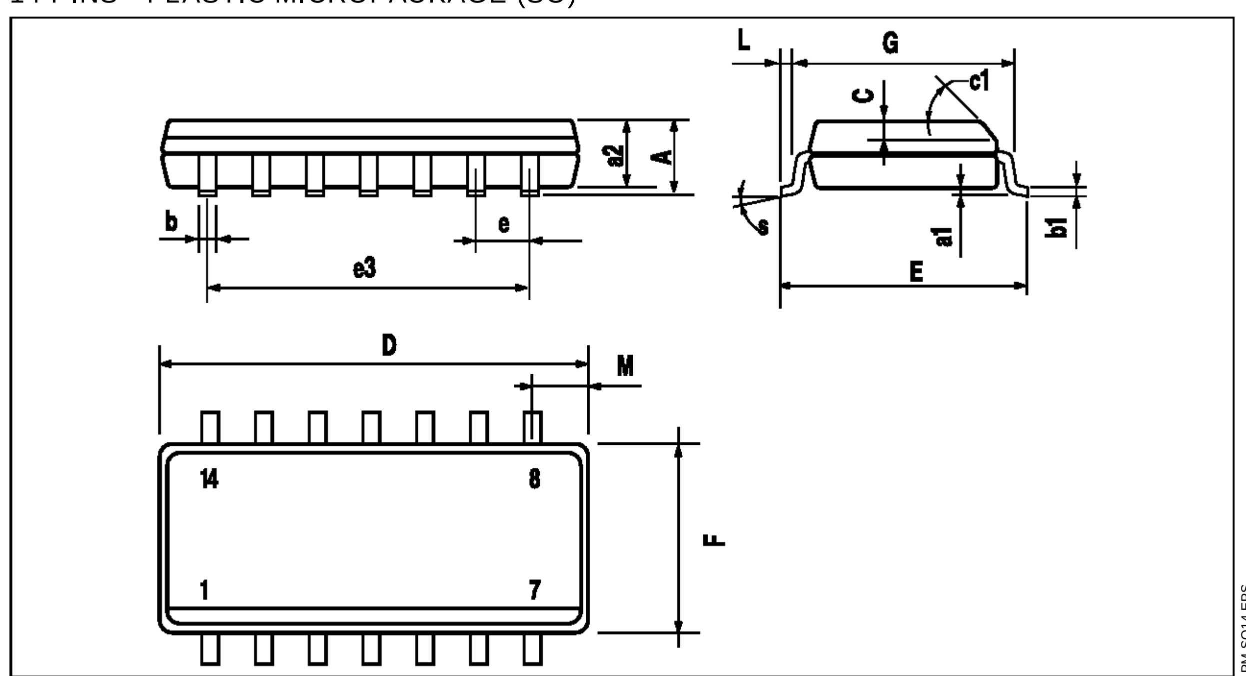


Dimensions	Millimeters			Inches		
	Min.	Typ.	Max.	Min.	Typ.	Max.
a1	0.51			0.020		
B	1.39		1.65	0.055		0.065
b		0.5			0.020	
b1		0.25			0.010	
D			20			0.787
E		8.5			0.335	
e		2.54			0.100	
e3		15.24			0.600	
F			7.1			0.280
i			5.1			0.201
L		3.3			0.130	
Z	1.27		2.54	0.050		0.100

DIP14.TBL

PACKAGE MECHANICAL DATA

14 PINS - PLASTIC MICROPACKAGE (SO)



Dimensions	Millimeters			Inches		
	Min.	Typ.	Max.	Min.	Typ.	Max.
A			1.75			0.069
a1	0.1		0.2	0.004		0.008
a2			1.6			0.063
b	0.35		0.46	0.014		0.018
b1	0.19		0.25	0.007		0.010
C		0.5			0.020	
c1	45^{o} (typ.)					
D	8.55		8.75	0.336		0.334
E	5.8		6.2	0.228		0.244
e		1.27			0.050	
e3		7.62			0.300	
F	3.8		4.0	0.150		0.157
G	4.6		5.3	0.181		0.208
L	0.5		1.27	0.020		0.050
M			0.68			0.027
S	8^{o} (max.)					

SO14.TBL

ORDER CODE :

